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THE ASPECT OF *JUPITER* IN 1889.*

BY JAMES E. KEELER.

The opposition of *Jupiter* in 1889 was a very unfavorable one for observation, the planet being at nearly its greatest possible southern declination. Nevertheless, as the conditions at most of the American and European observatories were even more unfavorable than at Mt. Hamilton, I examined *Jupiter* at Professor HOLDEN'S request, as often as circumstances would permit, and made drawings whenever the atmospheric conditions were sufficiently good. Usually a power of 320 was employed on the thirty-six-inch equatorial, and occasionally higher powers. On a few nights the twelve-inch telescope was used, and sometimes the six-and-a-half-inch telescope, in order to compare the appearance of the planet as shown by it with that presented by the larger instruments. As would naturally be expected the advantage of the thirty-six-inch equatorial was most marked on nights of fine definition, although on *all* occasions the larger telescope showed its superiority. Seen with the latter instrument on a fine night, the disc of *Jupiter* was a most beautiful object, covered with a wealth of detail which could not possibly be accurately represented in a drawing. Under these circumstances scarcely any portion of *Jupiter*, except the red spot and the extreme polar regions, was of a uniform tint, the surface being mottled with flocculent and more or less irregular cloud masses.

The main object of the observations was to record the aspect of the surface of *Jupiter*, showing all the details that could be perceived with the telescope and transferred to paper in the limited time allowed by the rotation of the planet. For accurately fixing the longitudes of the different markings and their times of rotation, observations of transits over the central meridian are more suitable, as in such work the attention can be concentrated on a single object. In making the drawings special attention was paid to the markings which seemed to be characteristic of the appearance of *Jupiter* at the opposition of that year.

Each drawing occupied from fifteen to twenty minutes. The work could not be continued after the expiration of that time, on

* The drawings of *Jupiter* given in this number were printed in the August and September numbers (for 1890) of the journal *Himmel und Erde*, published by the *Gesellschaft Urania*, in Berlin, and the present article is abridged from the accompanying German text.

account of the changes caused by rotation of the planet. All positions and dimensions are mere eye-estimates, but a few micrometer measurements made toward the end of the observations show that the estimates are fairly accurate. The errors of drawing have not been corrected in preparing the plates, which are faithful copies of the original records. Twenty-four drawings were made during the opposition, and of these, eight were selected for reproduction by lithography.

Description of the Principal Features of the Surface of Jupiter.

The equatorial zone, occupying the space between the red belts, was marked in the center of a salmon-colored stripe, which was occasionally interrupted by an extension of the white clouds on the sides of the zone. The edges were brilliant white, and were formed of rounded cloud-like masses, which at certain places extended into the red belts as long streamers. These streamers formed the most remarkable and curious feature of the equatorial regions. They are the cause of the double or triple aspect which the red belts present in small telescopes, and of which Dr. TERBY has given a description and drawing in *A. N.*, No. 2928. In this connection I may state that it did not require the thirty-six-inch equatorial to show this structure of the red belts, as Dr. TERBY seems to infer in a paper presented to the Belgian Academy of Sciences, for it could be seen, although imperfectly, with the six-and-a-half inch telescope, and with the twelve-inch telescope the streamers I have referred to were shown very distinctly. The thirty-six-inch telescope, which, being the most powerful instrument at my command, was naturally used in making these observations, brought vastly more difficult details into view; and if these are inadequately represented in my drawings, the fault must be ascribed to the draughtsman, and to the limited time allowed by the rotation of the planet.

Near their junction with the equatorial zone the streamers were white and definite in outline, but they became redder in tint toward their outer extremities, and more diffuse, until they were lost in the general red color of the background. When the seeing was good they were seen to be formed of irregular rounded or feathery clouds, fading toward the outer ends, until the structure could no longer be distinguished. These streamers, when long, invariably pointed toward the following limb of *Jupiter*, and from all observed appearances they were masses of cloud projected outward from the equatorial zone, and gradually left behind by the forward drift of the

equatorial regions. That there was a flow outward from the junction with the zone was determined by the motion of bright points, or knots, on the streamers. In the drawing of July 9, two such brightenings are shown on the streamer just below the red spot. On July 11, they were both somewhat farther from the root of the streamer, but the outer knot had moved farther than the inner one, so that the distance between them had increased, as shown in the drawing of this date. It was seldom, however, that spots sufficiently definite for such observations could be found.

In many cases two of these streamers were seen side by side, the outer one always having its origin nearer the preceding limb of the planet, as they never crossed. On no occasion were more than two parallel streamers seen, a third, where it met the other two, seeming to be crowded into the white outside boundary of the red belt, as in the drawings of July 10 and July 12. The portions of the equatorial zone surrounding the roots of well-marked streamers were somewhat brighter than at other places, and it is a curious circumstance that they were almost invariably suffused with a pale olive-green color, which seemed to be associated with great disturbance, and which was rarely seen elsewhere. It was not possible to indicate this in the drawings.

One part of the equatorial zone, in longitude about 228° , manifested a special degree of activity. It is shown in the drawings of July 15 and July 20. In this vicinity the changes of form seemed to be most rapid, and a few short streamers occur which bend in a direction contrary to the usual one. If we accept the explanation of the formation of streamers already given as correct, we may regard these short streamers as formed by clouds projected with a sufficient velocity to overcome for a short time the current due to the forward drift of the equatorial regions.

The red belts presented on all occasions the appearance of a passive medium, in which the phenomena of the streamers and other forms shown in the drawings were manifested. These phenomena would be exactly reproduced by streamers of cloudy white matter floating in a semi-transparent reddish fluid, sometimes submerged and sometimes rising to the surface, and it is by no means impossible that such is actually their nature. The dark spots frequently seen on the red belts usually occupied spaces left by sharp turns in the streamers, and they were of the same color as the belts, but deeper in tint, as if the fluid medium could be seen to a greater depth.

The great red spot on the southern hemisphere is shown in several of the drawings. It was of a pale pink color, slightly lighter in the middle. Its outline was a fairly true ellipse, framed in by the bright white clouds of the adjacent belt. The surrounding frame of white clouds was continuous, but it was very narrow at the south preceding end, so that when the seeing was poor the gray belt terminating at that place seemed to blend with the spot. The following end of the spot was marked by a dark shading.

In the plates the spot is shown slightly too small, an error which is due partly to the original drawings and partly to the process of reproduction. The length of the spot, as determined by a few observations of Mr. BARNARD'S, was about forty-three minutes of time, or (in projection) about 18,500 miles.

Following the red spot, the two white belts on the south faded into a broad, uniform gray belt, on which were numerous brilliant white spots, forming one of the most beautiful features of the surface of *Jupiter*. The smaller ones were round, and seemed to be bright knots on the faded ends of the belts just mentioned. Large oval spots, with smaller ones placed near them in a curiously symmetrical manner, follow in nearly the same latitude, and are shown in many of the drawings. An isolated white spot in a considerable southern latitude is shown in the drawings of July 10 and July 12.

The bright spots described above seemed to exert a repellent influence on the narrow belts in their vicinity, as may be seen by the arching away of the belts just above the spots in the drawings of July 10 and July 15, but it by no means follows that a repellent force actually exists. It was only on nights of good definition that this peculiarity could be observed.

The cloud-like appearance of the surface of *Jupiter* was most strongly marked in the series of parallel belts on the northern hemisphere. The appearance of these belts is occasionally beautifully reproduced in the sea of terrestrial clouds which sometimes pours through the valley west of Mt. Hamilton, under a clear sky and bright sun, far below the level of the observatory.

No white spots like those on the southern hemisphere were ever seen north of the equator. Dark spots occurred, but they were merely unusually dark cloud-masses in the spaces between the light belts. As in former years, the greatest activity in the internal forces of *Jupiter* was exhibited in the southern hemisphere.
